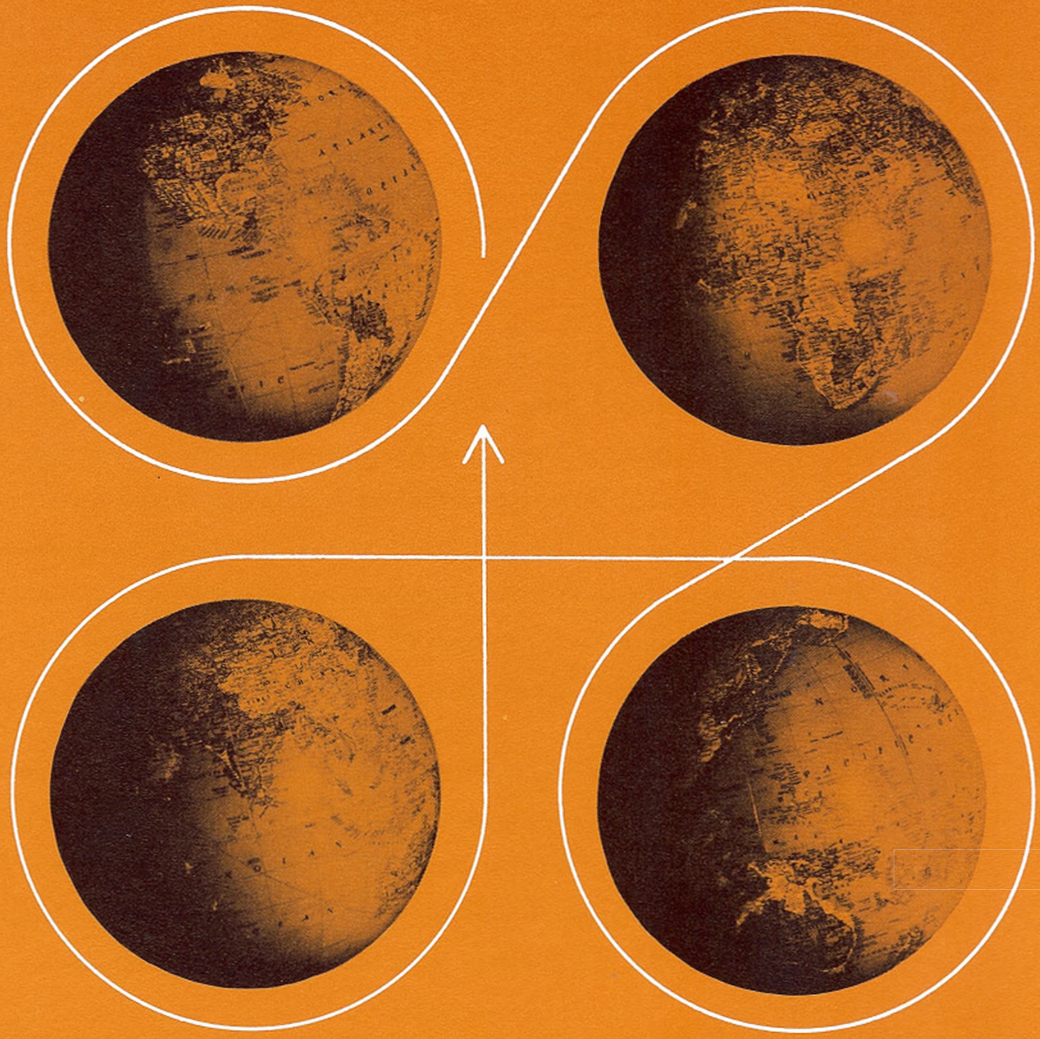

THE ECONOMICS OF TILAPIA CULTURE IN KASAI OCCIDENTAL, ZAIRE

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Cornell University, Ithaca, New York

December 1985

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IN

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by

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PREFACE

The field research for this study was funded through the Agricultural & Rural Development Division of U.S.A.I.D., Kinshasa. Richard Peters, the Head of the Division, and Dave Atteberry, the project liaison, were especially helpful in arranging logistical matters. I am deeply indebted to Brian Steinwand, the Peace Corps Director for Fisheries in Zaire, for all his support and assistance, and Bill Pruitt, the former Country Director, for his encouragement in the early stages. Thanks also go to the Director of P.P.F. in Kinshasa, Longangi Mughusu, and the Regional Coordinator in Kasai Occidental, Tshungu Kaswalo.

The survey would not have been possible without the outstanding cooperation of the Zairian farmers involved in the project and the many long hours put in by my principal assistant, Tshibuabua Binye, tracking down drop-outs and secondary adopters. Ntumba Kanoa, Mulokayi Ntambue, Kalala Lupanzula, Directrice Mwambilabo, Kabansua Mabingila, Lushimba Ngombi, Mukinyi Bakuala, Muanza Katumpamba, Pascal Mutombo, Amy Purvis, Paul Baglione, Willy and Freddy Rodriguez, and Steve and Trish Cavell, all contributed to the completion of this study.

The data were analyzed under the direction of Jon Conrad and Ken Robinson in the Department of Agricultural Economics at Cornell University. Technical support for completing the thesis work based on this research was also provided by Jim Pratt, Lillian Thomas, and Thomas Randolph. Special thanks go to Ken Robinson for his assistance in editing the manuscript for this publication and to Judy Watkins for typing the final draft.

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INTRODUCTION

During the past two decades, there has been a substantial growth in the number and variety of aquaculture projects in developing nations. Research has focused on overcoming the biological and technical problems inherent in various types of maritime and inland systems. By comparison, there is a relative dearth of reliable information available on the economics of new production systems or their sociocultural impact, particularly for projects undertaken in Sub-Saharan Africa. This report is designed to provide such information by examining the adoption and viability of an introduced system of tilapia production in the Region of Kasai Occidental, Zaire.

Raising tilapia is one of the simplest forms of animal husbandry that can be widely adopted by low-income farmers. All tilapia exhibit a high degree of disease resistance, can withstand low oxygen levels and reproduce prolifically in small bodies of water.[1] In addition, many species can exploit a wide range of food resources including plancton, leaves, and grain by-products.

Tilapia production in ponds is a labor intensive operation. Under good conditions and where adequate feed is available, it can yield returns to labor and land superior to certain other food crops, such as maize and peanuts.

Project Pisciculture Familiale (P.P.F) is a small-scale fish culture project in Zaire designed to encourage intensive feeding of tilapia (Oreochromis niloticus) in earthen ponds. The project had its

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[1] In many African and Asian countries, tilapia culture is not popular because of what is viewed as "excessive" reproduction. Over 50% of the fish in a typical harvest may be too small to be marketed. This is not the case in Zaire, where all sizes of fish are eaten and in some instances, smaller fish have even been known to sell for a higher price per kilogram.

antecedents during the colonial period. Pond culture in Zaire was extensively promoted by the Belgians during the 1940s and 1950s, but was virtually abandoned during the turmoil following independence in 1960. The current project grew out of a joint pilot program initiated by Peace Corps and OXFAM in 1975 to reintroduce tilapia culture in the Bandundu Region using improved management techniques with Peace Corps volunteers serving as extension agents.[2]

A principal objective of the project is to improve the well-being of subsistence level households by increasing the availability of protein and providing a source of cash income. The extension effort was primarily geared towards providing rural male farmers with an activity that complemented crop production. Each extension agent was expected to cover a radial area of up to 40 kilometers from his/her home base. The operational philosophy focused on locating and training a core group of model individuals who would be visited on a weekly or bimonthly basis. It was felt that the key to a successful extension effort was for the agents not to spread themselves too thin, but to concentrate on thoroughly training a maximum of 25 to 30 farmers over a two-year period. Since demand often exceeded this number, the selection process was based on the extension agents' assessments of a number of very subjective criteria in addition to physical considerations at the site itself. Direct contact between extension agents and rural farmers was viewed as the best way to transmit information to farmers having at best some primary school education. In order to achieve yields on the order of 4000 to 6000 kg/ha/year or even higher, farmers were encouraged to feed twice daily, compost on a regular basis using animal manures and other vegetal material, and do regular maintenance on the dikes and canals. The resulting harvests of these progressive farmers were thought to be the most effective form of propaganda for encouraging others to participate.

The expansion of fish culture into the region of Kasai Occidental began on a pilot basis in 1977 with the placement of two extension agents

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[2] For a description of the management techniques employed in small-scale tilapia culture refer to Torrans (1973), Chakroff (1976), and Balarin & Hatton (1979).

in the Zones of Luiza and Tshikapa. By the following year, the initial successes seen in the Bandundu area led to the involvement of the United States Agency for International Development (U.S.A.I.D.) and the Government of Zaire (G.O.Z.) under the auspices of Projet Pisciculture Familiale.[3] Their joint efforts led, in 1979, to expanding the area covered to include three additional posts in the Zones of Luiza, Dibaya and in the urban center of Kananga. In 1981-82 three additional rural Zones were incorporated into the program (Kazumba, Demba, Mweka). By mid-1983, sixteen volunteers were in the field (see Figure 1), a regional office with a staff of four Zairians had been established, and a fingerling/demonstration center had been constructed on the outskirts of the city.

The pages which follow summarize the results of a study conducted between October 1983 and February 1984 to assess the factors associated with success or failure of tilapia production. Field work was undertaken in three locations in Kasai Occidental where the extension program had been originally initiated. The primary data gathered consisted of interviews with both project and non-project fish farmers as well as non-participants and direct observation of ponds, related production activities and marketing practices.

The three areas included in the study differed greatly with respect to the physical characteristics suited to pond construction (type of soil and water availability); alternative earning opportunities; proximity to markets; and population density. The first area (Luiza) is designated hereafter in the report as the one most favored for agricultural production; the second area (Dibaya) is less favored for agricultural production, and also for pond construction; the third area (Kananga) lies in an urban center where the population density is extremely high.

In the most favored area (Luiza) soils were predominantly clay, and thus had good potential for pond construction. In addition, there were numerous small valleys suitable for building ponds. The majority of farmers had access to a variety of leaves (manioc, sweet potato, papaya,

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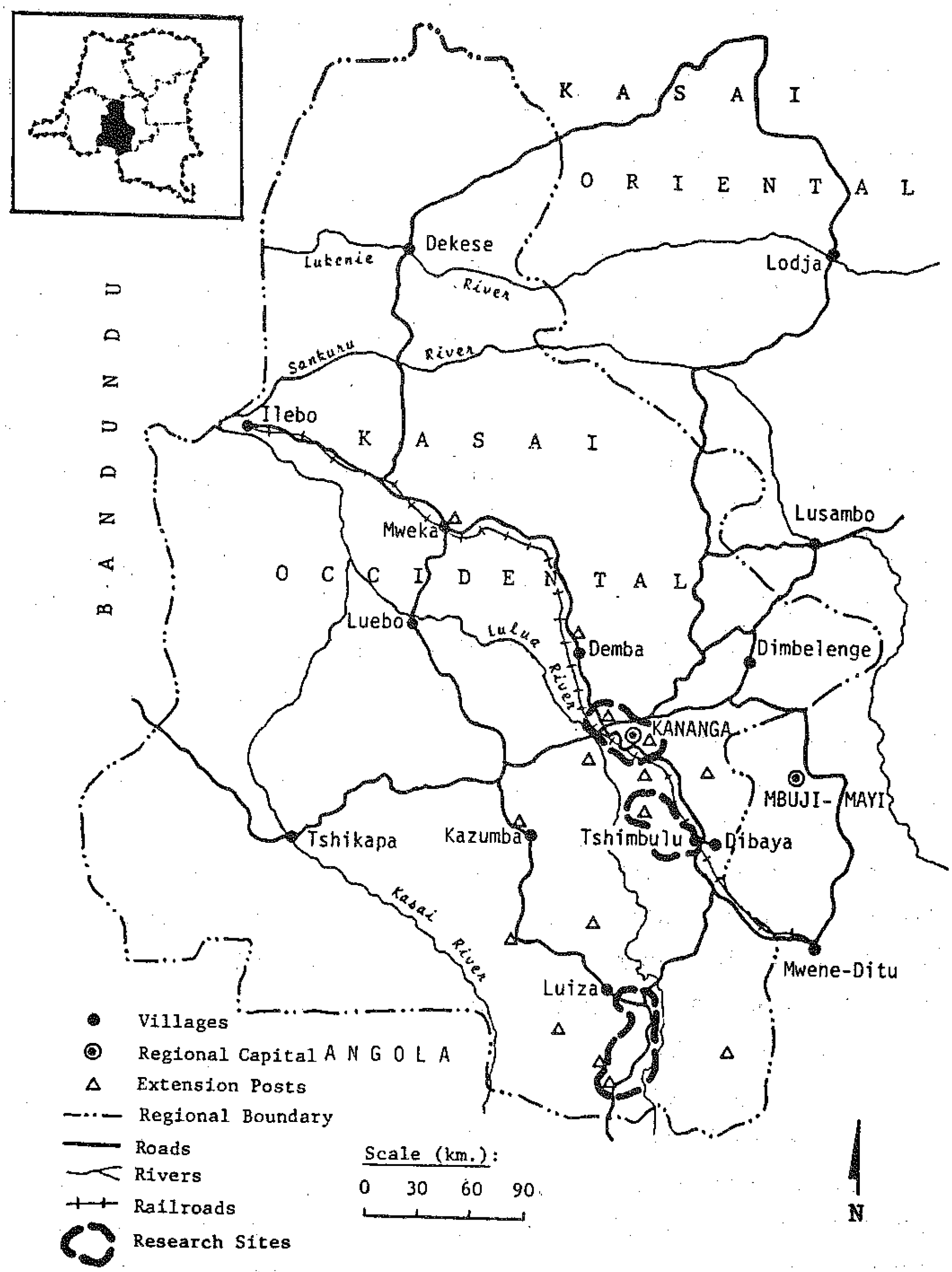
[3] The total commitment of the three agencies (Peace Corps, U.S.A.I.D., G.O.Z.) over the six year life of the project (1978-1983) was $5,043,000. Of this, U.S.A.I.D. contribution to the project (Number 660-0080) was $900,000.

Figure 1. Extension Posts and Research Areas in Kasai Occidental, 1983



etc.) and termites for feed and some animal manure for composting. Hoes and machetes were produced by local blacksmiths in the area, but shovels were in short supply since they came from Kananga, although occasionally limited quantities could be bought through local missions. Major weekly village markets were located throughout the Zone, but the majority of fish were sold at pondside. Fresh fish was widely available at certain times of the year, especially within five to ten kilometers of major rivers, and was price competitive with pond-produced tilapia.

In the less favored agricultural area (Dibaya), soils were lighter and the population density was higher. Valley quality varied greatly within the Zone, ranging from broad, lightly forested swamps to narrower valleys with year-round sources of water more suitable to fish culture. Leaves and termites were also available as feed, and many farmers used rice bran during the dry season. Less animal manure was available, and there was more competition with dried fish because it lay on the rail line coming up from Shaba. River fish was also prevalent at certain times of the year. Because the area is closer to Kananga than was Luiza, obtaining non-locally produced tools was not as difficult logistically as it was in Luiza.

The resource base in the urban area (Kananga) was not especially well-suited to tilapia production, but the project was readily accepted because of the availability of brewery waste and mill sweepings as feed and because urban families were eager to have an additional source of income. Manioc leaves were principally used for human consumption, not fish feed. Animal manures existed in limited quantities. All tools were readily available, except wheelbarrows. Whether or not the farmer could afford to purchase them was another matter. Two major markets existed, plus several smaller ones located throughout the city. River fish were expensive and in short supply in spite of the fact that the Lulua River was only five kilometers from the outskirts of the city.

Objective measures of well-being reflected differences in the resource base. Households in the most favored area (Luiza) had houses in the best condition, were generally self-sufficient in manioc and maize production and owned more livestock (especially cattle). Fewer households in Dibaya were self-sufficient in manioc and maize production but benefited from closer proximity to Kananga which simplified marketing of crops and facilitated small-scale trading. The only apparent benefit to living in the urban area (Kananga) was access to better educational facilities, especially for girls.

Samples for the survey were drawn so as to represent initial adopters (those selected by the extension service), drop-outs from the program, and those who had begun raising fish with little or no technical assistance (secondary adopters).[4] In total, 153 farmers were interviewed, of which 46 were initial "model" adopters still raising fish; 44 were secondary adopters, of which 54% had never had any contact with the extension service; 26 were individuals who had abandoned their ponds, and 37 were non-participants.[5] This information was supplemented by direct observations of pond-related activities, surveys of market prices, and statistics from government sources and local businesses.

Number of Participants, Pond Size and Yields

The overall size of the extension program is indicated by the figures in Table 1 which summarizes the number of "project" farmers having direct contact with the extension service during 1983 for the Zones included in the survey. These figures provided by extension agents who were operating in the field are fairly accurate but limited in scope. This is due to the fact that only the thousand or so farmers who were being visited at that time are accounted for in the quarterly reports. Secondary adopters are excluded whether or not they received

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[4] The households included in this survey were broken down into several categories before being analyzed. In instances where there were significant differences between the responses given by initial adopters and other fish farmers, information for the initial adopters is presented separately. Replies from secondary adopters and drop-outs in the rural areas were often combined due to the small sample size of each of these groups and the fact that all but one of the drop-outs interviewed had previously been secondary adopters. When categorical variations were not great, all initial adopters (I), secondary adopters (S), and drop-outs (D) were combined into one "pond-owning" category for each particular zone. Non-participant data (N) were complete for both rural areas, but not for Kananga due to the use of a shortened version of the questionnaire. For more details concerning the methodological procedures used to select survey participants, refer to Low, J.W. "The Economics of Tilapia Cultivation in Kasai Occidental, Zaire", M.S. Thesis, Cornell University, January 1985.

[5] For a summary of the characteristics of households included in the survey, see Appendix A.

any extension contact. Moreover, yield statistics are recorded only for those harvests where the agent actually was present or for cases where farmers utilized scales and informed the agent of their results. Unquestionably, the figures are incomplete and underestimate the total impact of the project.

Table 1. P.P.F. Extension Program in the Survey Areas: 1983

	LUIZA	DIBAYA	KANANGA
Number of Posts in Zone[a]	5	3	2
Number of Farmers Receiving Extension Services in 1983	689	133	323
Number of Tilapia PONDS	361	188	239
Area under PRODUCTION (hectares)	4.64	1.51	3.01
Average YIELDS (kg/ha/year)	4183	3267	3500

[a]As of mid-1983. All production figures from the Katuishi Fish Station in Kananga are excluded.

The average yields shown for P.P.F. farmers are far higher than those recorded at the major government center in Kasai province during Belgian times (1900 kg/ha/year). The introduction of a new species combined with intensive management skills led to improved individual farmer performance. While the average yields attained by model farmers were less than those for the regional fish station at Kutuishi (6000 kg/ha/year) and far below maximum yields recorded for <u>O</u>. <u>niloticus</u> elsewhere in the world (8 to 15,000 kg/ha/year), they still were higher than those obtained during the colonial years.

The lowest overall yield figure (3267 kg/ha/year) was found for current project participants in the Dibaya Zone. This is not surprising given that this area has poorer soils for both crop and fish production than in Luiza, yet lacks the grain by-products used for feed in the city.

There was a significant difference in the urban and rural areas between the average number and size of ponds per farmer (see Table 2). Initial adopters in Kananga had 15.6 ares per person; those in Luiza 8.6

ares; and those in Dibaya 4.7 ares per person.[6] Initial adopters had at least twice as many ares per farmer as did secondary adopters. Moreover, the average size of the largest pond owned by a secondary adopter was under one are, the recommended minimum size advocated by the extension service. In the city, this contrast is partly a function of initial adopters having claimed the best and most extensive sites before competition for land on the valley floors became so intense.

Table 2. Average Quantity and Size of Ponds

	Kind of Adopter	RURAL AREAS More Favored (Luiza)	RURAL AREAS Less Favored (Dibaya)	URBAN AREA Kananga
Ponds Per Farmer:	Initial	5.2	3.8	7.4
	Secondary[a]	3.3	2.6	4.8
Ares Per Farmer:[b]	Initial	8.6	4.7	15.6
	Secondary	2.1	1.6	6.7
Ares Per Pond:[b]	Initial	1.6	1.2	2.1
	Secondary	0.6	0.7	1.4
Size of Largest Pond (Ares):	Initial	2.4	2.3	4.4
	Secondary	0.8	0.9	2.1

[a]Includes those who had abandoned their ponds at the time of the survey as well as farmers who were still raising fish.
[b]One are equals 100 square meters.

Labor Supply and Labor Use

Participants in the project relied mainly on family labor for pond work, including the amounts required for construction, feeding, harvesting and marketing. An average of 4 to 6 adults was available per household (see Table 3). The average number of adults involved in pond work was about the same for secondary adopters as for initial adopters, but the extent of female participation and the contribution of children varied among households. Initial adopter households in the urban area (Kananaga) had a smaller pool of adult labor to utilize in pond work

[6] One are equals 100 square meters. There are 100 ares in a hectare.

than did those in the two rural areas. Only 55% of the pond labor force in initial adopter households in Kanaga was supplied by adult men and women compared to 74% in Luiza and 67% in Dibaya.

Table 3. Average Number of Persons Per Household Involved in Pondwork

Labor Supply	LUIZA I	LUIZA S+D	DIBAYA I	DIBAYA S+D	KANANGA I	KANANGA S+D
	(Number per Household)					
Males in Pondwork						
6-15 years old	0.9	0.8	1.8	0.4	1.5	1.1
>15 years old	2.1	1.5	2.5	1.5	1.7	1.9
Females in Pondwork						
6-15 years old	0.5	2.0	0.5	0.9	1.2	0.9
>15 years old	1.9	3.2	2.1	1.5	1.6	1.2
Total AVAILABLE POOL of Adult Labor	5.1	6.0	5.2	4.2	4.1	4.4
Total SUPPLY OF LABOR in Pond Culture						
Adults Only	4.0	4.7	4.6	3.0	3.3	3.1
Adults plus Children	5.4	7.5	6.9	4.3	6.0	5.1

While all households relied mainly on family labor for pond construction, most initial adopters also hired neighbors and relatives to assist in building the ponds. Payment in the rural areas was principally by providing food and drink. Although cash remittance dominated in the urban sector, approximately one quarter of the pond operators in Kananga did all the construction on their own.

Composting duties were usually undertaken by the principal fish farmer in the household. The assistance of older women in rural households was significant, particularly in Dibaya. Women's activities in composting were often centered around transporting manures and wastes, and occasionally in gathering leaves. Men were almost always responsible for cutting the grass on the dikes, as activities requiring the coupe-coupe[7] fell within their domain. Often such cut material was added to the compost pile. Consequently, the males of the household performed most of the work associated with composting.

The responsibility for supplementary feeding was often dispersed among various household members. Males of all ages were significant participants in supplementary feeding in rural initial adopter households. The same held true in Kananga, except for males 16 to 30 years of age. The contribution of both children and adult women in supplementary feeding was much greater than in composting.

Harvesting and marketing of a pond of tilapia in the vast majority of cases took place in one day. Only a few urban households reported drying any fish from the harvest for later consumption. Thus, the scheduling of the harvest during a time of year when demand was high was an important factor for the majority of farmers.

Although fish marketing is typically viewed as a woman's activity, adult men in initial adopter households in Luiza and Kananga also were heavily involved in the marketing process.[8]

Feeding Practices

The nutritional benefit of supplementary feeding is obvious—annual "natural" production in ponds alone rarely exceeds 6 kilograms per are. There are two ways in which natural feed supplies may be augmented: by encouraging plancton growth through composting, and by providing "supplementary" feeds such as leaves, termites, and farinaceous by-products. Decomposition of unutilized supplementary feed also contributes to plancton growth.

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[7] A coupe-coupe is a long-bladed tool curved at the end. Sharpened on both sides, its principal use is for cutting grass.

[8] Data from the most recent harvest indicated that 44% of the male fish farmers in initial adopter households in Luiza sold the fish themselves, compared to 29% of them in Kananga, and only 12% in Dibaya. The greater involvement of men in marketing in rural Luiza may be due partly to their reported authority within the household regarding decisions on cash expenditures. Several households in Dibaya and Kananga, on the other hand, indicated that the guarding and spending of household funds was either under the female head of the household's jurisdiction, or jointly decided.

Composting was the most difficult practice to have Kasaian farmers perform on a regular basis, mostly due to their lack of experience with the technique in general, but also because of difficulties involved in obtaining and transporting animal manures. Although fish farmers in the more favored area (Luiza) owned more animals on the average than did those in the other two areas, only 31% of the initial adopters in Luiza reported that they composted all of the time. The percent of initial adopters composting all the time was much higher both in Dibaya (53%) and Kananga (61%) than in Luiza. However, the use of animal manure by those who did compost was highest in the more favored area. As expected, secondary adopters relied more on just leaves and grasses for composting materials than did the initial adopters.

In the rural areas, cash was rarely used to purchase fish food. Ninety-three percent of initial adopters in Dibaya, and 100% of those in Luiza, bought no feed at all in 1983. Fourteen percent of the rural secondary adopters purchased manioc waste, 14% bought rice bran, and the remaining 72% nothing at all. The same was not the case for Kananga, where the majority of both the secondary and initial adopters purchased at least one kind of feed during 1983. Brewery and manioc waste were the main feeds purchased. These were combined with many other sorts of leaves, except manioc. Maize waste and the debris left from the sacks of dried fretin from Kalemie were also used but to a lesser degree.[9] Secondary adopters who did purchase feed bought smaller quantities but made purchases nearly as frequently as did the initial adopters.

Extension agents advocated feeding pond fish twice a day, once in mid-morning and again in the late afternoon.[10] The majority of participants fed at least once a day. In the rural areas, substantial numbers of initial adopters reported not feeding at all or on a very irregular basis (Table 4).

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[9] Fretin (in French) or mayela (in Tshiluba) refers to the finger-sized, dried Stolothrissa tanganicae principally from Lake Tanganika in Eastern Zaire.

[10] The timing of feeding is also related to temperature. Tilapia stop feeding when temperatures drop below 14 degrees Centigrade. During the dry season, fish frequently do not become active until late morning.

Several factors other than availability of feed may have influenced feeding frequency. These include: 1) the distance from the farmer's home to the pond, 2) the presence of fields next to the ponds, 3) the frequency of extension contacts with the farmer, 4) the amount of time available for gathering food, 5) whether or not the person(s) in charge of feeding the fish was (were) frequently absent, and 6) weather.

Table 4. Frequency of Fish Feeding Among Pond Operating Households (Percent of Total Number of Households Surveyed in 1983)

	INITIAL ADOPTERS			SECONDARY ADOPTERS	
Frequency	Luiza	Dibaya	Kananga	Rural	Kananga
Twice a Day	15	33	39	20	50
Once a Day	39	40	44	50	35
2 to 3 Times per Week	0	0	6	20	3
Once a Week	23	7	11	0	0
Irregular	23	0	0	10	6
Don't Feed	0	20	0	0	6

The Contribution of Pond Culture to Income and Family Diet

The benefits of engaging in pond culture were assessed from two standpoints: the production of fish for home consumption and the sale of tilapia as a means of generating income. Tilapia production made a significant contribution to income in more than half of the households surveyed. It was among the top 3 income-earning activities in 63% of the pond-operating households in Luiza, 50% of those in Dibaya, and 64% of those in Kananga. The importance of pond culture as a means of generating income was most significant in the urban sector where cash was needed to purchase basic food staples. In rural areas, the ability to obtain cash during times of the year when other sources of income were not available was often as important to fish farmers as the actual amount earned.

The income gained from selling tilapia complemented but did not surpass that from crop sales in most rural households. Only 31% of the initial adopters in Dibaya and Luiza reported that they made more money from their ponds than they did from sales of their top 3 cash-earning crops in 1983. In contrast, all Kananga initial adopters who sold some produce from their fields found fish cultivation to be more profitable. Most secondary adopters, both rural and urban, stated that their crops earned them more money than selling tilapia.

In all three areas, income generated from the ponds was used to help meet the basic needs of the household. Manioc and maize dominated purchases in the urban sector, while rural expenditures were mainly for articles imported from the city (clothes, soap, and salt), school fees, or buying livestock. Other uses included paying off a debt, obtaining medical care, and purchasing fish food. No expenditures on such luxury items as radios and bicycles were reported.

In an absolute sense, total production and income generated annually from the sale of fish were greater in the relatively prosperous rural zone of Luiza than in the poorer rural zone of Dibaya. Fish farmers on the average in Luiza built more and larger ponds than did their Dibaya counterparts. However, the relative contribution of pond culture may be greater for Dibaya households because fewer income earning opportunities exist and crop production provides lower returns than for Luiza families. Both initial and secondary adopters in Luiza made approximately 3.5 times more from the sale of their most important crops than did those in Dibaya. This raises the question as to whether, in the rural sector, the extension effort should concentrate in areas of greatest need, not necessarily those which are better endowed from a purely technical standpoint.

Much of the benefit from pond culture was derived from having a year-round supply of protein for home consumption. In areas possessing a constant water supply, pond culture was highly complementary to manioc production. The fresh tilapia served as a year-round source of animal protein to balance the predominantly carbohydrate diet during those times of the year when the supply of alternate sources of protein declined.

One of the most popular times for harvesting fish was during the dry season since there was no rain to impede the harvesting and marketing process. The fact that the harvest date could be timed to meet critical income needs enhanced the overall value of the ponds.

Maximum benefits form the sale of tilapia occur to the household at times when the cash needs of the family coincide with a high demand for fresh tilapia. As they gained experience operating ponds, farmers tended to extend or shorten production periods so that harvesting occurred at more desirable times. In rural areas, the greatest need for cash for farmers in the survey fell around the months of July, August, September, October, and at holiday time in December. In June and July, involvement in pond activities was highly complementary with a lull in agricultural work. By late July and August, however, male labor supply became constrained by having to clear forest land for cultivation. Both male and female availability for pond culture declined significantly during crop planting time in September, weeding time in November, and during the months of December and January when the first season's crop would be harvested and land prepared for the second planting.

From the point of view of cash generation, the worst months for harvesting were February and March, which fortuitously coincided with a diminished need for cash in the rural sector.

Harvesting decisions by Kananga fish farmers were less influenced by seasonal fluctuations in competitive protein alternatives than by the monthly fluctuation of income in households of salaried workers. The majority of initial adopters scheduled their harvests on or about payday for government employees.

The demand for tilapia is relatively high because of its lower price per kilogram when compared to other meats and animal by-products such as milk and eggs (see Table 5). However, tilapia producers had to compete with many other kinds of fish. The greatest competition faced by urban fish farmers is from the less expensive salted fish or, more recently, the higher-priced, but meatier frozen mackerel. In rural areas, producers face competition from fresh river fish on a seasonal basis, and occasionally dried fish as well. Tilapia cannot compete on a cost per kilogram basis with vegetable sources of protein such as peanuts and beans; however, the latter are susceptible to large seasonal fluctuations in supply.

Table 5. Cost Per Gram of Protein of Selected Protein Foods[a]

FOOD	% Protein Content[b]	Kananga	Luiza	Dibaya
		(Zaires per Gram of Protein)		
Fresh Tilapia	12	.45	.29	.25
Salted Fish	59	.12	.19	.15
Sardines	24	.67	.87	.92
River Fish	19	N.A.	.34	N.A.
Beef, without bone	18	.89	N.A.	N.A.
Egg	10	2.40	.40	1.60
Milk, powdered	35	.64	.93	N.A.
Termites (nsua)	52	.20	.10	.10
Manioc Leaves	7	.08	N.A.	.11
Amaranth Leaves (tshiteku)	5	.30	.12	.26
Beans	23	.10	N.A.	.11
Rice, decorticated	8	.27	.16	.22
Maize, decorticated	9	.13	.03	.04
Manioc, dried and peeled	2	.85	.24	.28

[a]Market prices as of January 1984 for Dibaya and Kananga and as of November and December 1983 for Luiza. Based on measurements from a single purchase of each item in the market.

[b]Per 100 grams edible portion. Values from various sources: Balarin and Hatton (1979, p. 3); Oomen and Grubben (1978, p. 36), and U.S.D.A. (1981).

N.A.: Not Available. This does not mean that the product is never present in that market, but rather that it was absent at the time when the price survey was conducted.

A high proportion of tilapia harvested was reserved for family use, and a substantial amount of fishing from the ponds occurred between harvest times. Sixty-three to 73% of initial and secondary adopter households in the research areas reported that they did some fishing on a regular basis. As a result, yield figures based on harvest weights alone understate actual production levels attained. Estimates of production lost due to fishing were made on the basis of farmer responses. Using a value of Z40 per kilogram for 1983,[11] the total worth of tilapia obtained by fishing for home use ranged from an estimated low of Z320 in Dibaya to Z720 for Kananga.

The preference for home consumption over market sale is likely to increase if the purchasing power of the Zaire continues to decline, particularly in the urban areas. In Kananga, the rise in the price of tilapia often lagged behind that of more basic foodstuffs. Twenty-five kilograms of fish that purchased 4.5 sacks of manioc in October of 1981 could buy only 1.25 sacks in December of 1983. To counter this trend new marketing strategies might be adopted, such as smoking fish or selling smaller quantities at a time. The cost of smoking fresh tilapia for the urban market was examined and found to be economically feasible, but probably advisable only for those farmers producing large quantities of fish on a regular basis (see Appendix B).

<u>Returns to Labor and Land from Pond Culture Relative to Subsistence Crops</u>

Data limitations make it impossible to compare with any degree of precision the returns to labor from tilapia production versus crop production. The relative worth of the two activities can be approximated, however, by employing labor figures collected during the colonial period. Returns to land and labor from the production of one are of manioc, maize, or peanuts

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[11] The worth of the currency, the zaire (Z) has continuously declined since 1976. A dramatic devaluation occurred on September 10, 1983, with the value of Z1 plummetting from 17 to 3.6 cents. The new exchange rate of Z29.9 equal to $1.00 was close to the black market rate which had been Z30 to Z35 to the dollar. The exchange rate was to be periodically readjusted to keep pace with any parallel market that might develop. As of May 23, 1984, Z35.69 equalled $1.00 (Q.E.R., 1983, 1984).

compared with that from a well-managed pond system are shown in Table 6. In estimating the amount of time needed to produce 25 kilograms of tilapia from a one are pond it was envisaged that anywhere from 15 to over 90 person-days would be required to construct the pond and canal system. The lower figure corresponds to a non-forested, sandy area that had a nearby source of water. The opposite extreme is more representative of conditions found in Luiza—where forested valleys and clay soils predominate. When these values are combined with the high and low estimates of labor time for composting, feeding and maintenance plus an average value of 2.4 person-days for harvesting and marketing, total labor input ranges from a low of 29.4 to a high of 162.9 person-days per are. The low labor input scenario corresponds to a farmer who develops a non-forested site, has access to supplementary feed and a ready supply of composting materials. The high labor input case reflects less favorable conditions for pond construction, a reliance on leaves as the primary feed, and the need to transport composting materials a considerable distance.

Following the initial six month production cycle, the substantial labor input required for clearing and construction can be dropped. It is not unreasonable to speculate that construction time for any additional ponds would be lower than for the first as the canal system is already in place. The same logic does not hold with respect to feeding time in the rural sector where any increase in the number of ponds built leads to rising requirements for labor as pressure mounts on existing feeding supplies.

As can be seen in Table 6, tilapia production is a labor intensive operation that provides a high gross return per unit of land in both the urban and rural sectors. In the rural areas, tilapia production gives lower returns to unit labor input than does maize or peanut production during the pond's first production cycle if the farmer is required to spend a large amount of time collecting composting material and feed. In subsequent years, the return to labor from tilapia production could equal or exceed that obtained from maize or peanut production. Returns to labor from fish production are much lower than from manioc in both instances but a substantially longer production period is required to cultivate one crop of manioc (18 to 24 months vs. 6 months for tilapia).

Table 6. Comparative Return to Land and Labor of a Well-Managed Pond Versus Crop Cultivation, December 1983-January 1984

	CROP PRODUCTION			TILAPIA PRODUCTION[a]			
	Manioc	Maize	Peanuts	Initial		Subsequent	
				Low	High	Low	High
Labor Input[b] (Person-days per are)	7.3	2.5	4.2	29.4	162.9	14.4	73.9
Average Yield[c] (Kgs. per are)	87.0	7.4	5.4	25.0	25.0	25.0	25.0
Gross Return to One ARE of Production (Zaires)[d]							
Rural Sector	487.2	37.0	37.8	1000	1000	1000	1000
Urban Sector	1444.2	85.8	101.5	1125	1125	1125	1125
Return to LABOR (Zaires per Person-day)							
Rural Sector	66.7	14.8	9.0	34.0	6.1	69.4	13.5
Urban Sector	197.8	34.3	24.2	38.3	6.9	78.1	15.2

[a] Initial production period includes labor requirement for pond construction. Labor estimates were derived from answers to the limited, more detailed survey. Fifteen person-days per are was the lowest and 90 days the highest of the recall values reported for site clearing and pond construction in initial adopter households. Low and High columns represent the range of possible labor inputs given the different conditions faced by farmers.

[b] Crop production values are from man-day requirements for one hectare of production for Zaire as reported in INEAC (1958). The high value for manioc is due to the extensive amount of labor that goes into post-harvest treatment.

[c] Yields for crops were the mean value of yield figures for all Zones as noted in the 1980/81 crop figures released by the G.O.Z.

[d] Based on prices gathered in all areas during December 1983 and January 1984. Prices are for peanuts in shells, dried and peeled (but not ground) manioc, and decorticated maize. The representative value of Z40 was used for fresh tilapia in the rural sector, Z45 for the urban area.

Because of the higher prices received for crops in the urban sector, the unit return to labor for pond culture cannot compete with that from crop production when a high labor input is needed for feeding, composting and maintenance tasks. However, the higher return per unit of land for tilapia culture takes on added significance in the urban setting as many individuals do not have access to sufficient land suitable for crop production. The potential return to labor employed in raising fish is greater than that from peanut and maize production in both the initial and subsequent years when farinaceous by-products are available.

Problems Encountered by Program Participants

Initial and secondary adopters of the Tilapia program were asked to list the principal problems encountered in pond culture. Their responses are shown in Table 7. Inadequate feed supplies for the fish, pilfering, losses by predators, and insufficient labor or shortages of tools were the major problems listed by participants in the survey.

Table 7. Most Important Problem Encountered in Raising Fish
(Percent of Initial and Secondary Adopters Citing Each Response)

INITIAL ADOPTERS		SECONDARY ADOPTERS	
Luiza:		Rural:	
Excessive theft	(31)	Obtaining enough fish food	(50)
Lack of tools	(23)	Predators: birds & iguanas	(20)
Feeding fish is hard work	(15)	Excessive theft	(10)
Lack of sufficient labor	(8)	Buyers want fish on credit	(10)
Poor yields	(8)	Too many small fish at harvest time	(10)
Difficult to haul manure	(8)		
Lack of sufficient time to work on ponds	(8)		
Dibaya:			
Obtaining enough fish food	(27)		
Excessive theft	(20)		
Predators: birds & iguanas	(20)		
Lack of tools	(13)		
Lack of manure	(7)		
Poor yields	(7)		
Work is too hard	(7)		
Kananga:		Kananga:	
Obtaining enough fish food	(55)	Obtaining enough fish food	(50)
Lack of tools	(17)	Excessive theft	(26)
Excessive theft	(11)	Lack of tools	(12)
Hassles from local officials	(6)	Poor yields	(6)
Problems with wild fish	(6)	Predators	(3)
Illness	(6)	Lack of sufficient labor	(3)

Shortages of Labor and Equipment: On the whole, problems encountered by farmers during the construction phase tended to be less severe than those entailed in managing the ponds. A major obstacle is the clearing of land, the uprooting of palm trees being particularly strenuous and time-consuming. The most frequent complaint was not the lack of labor available for pond construction but lost time due to back and arm strain, skin infections, fever and other illnesses resulting from the hard work of pond construction.

Land in the rural sector usually could be acquired free of charge;[12] previously exploited sites in Kananga could be purchased at a low price per square meter.[13] Items such as machettes and hoes that were used in crop production also were available for pond construction. Shovels, however, were sold on an irregular basis in the rural areas and, if available, were rather expensive to purchase.[14] A substantial proportion of shovels found both in the rural and urban households were either broken or in extremely poor condition. Tools were frequently borrowed from family or friends when constructing a pond. Functioning wheelbarrows were virtually non-existent in all households.

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[12] As is the case in many parts of Africa, most Zairian land is controlled by all members of the community group or clan. Non-clan members acquire use rights on land through marriage, special arrangements with the village head, or agreements made through local or regional administrations. National legislation passed on July 20, 1973 stated that officially all land is the exclusive, unalienable, and imprescriptible property of the state (Mwamufiya, p. 23). In practice, most site selection for crop production in less-populated rural areas was either an individual decision or determined by the village chief, often in conjunction with the local agronome, just before the beginning of the cropping season.

[13] Resale figures for ponds in Kananga reported by the four initial adopters who kept records of purchases indicated that although the extremely low nominal prices per square meter that prevailed in the mid-1970s had doubled or tripled by 1983 to values ranging from Z1.3 to Z1.7 per square meter, the total price of the pond never exceeded what could be earned from one fairly well-managed six month production period.

[14] Since 1979, the nominal prices for both machettes and shovels in Kananga have risen at a faster rate than the price of tilapia. For example, in 1979 one kilogram of fish was equivalent in value to 5.7 machettes; by January 1984 one kilogram of fish would not have been enough to purchase even a single machette. Similarly, one shovel was equivalent to 1.3 kilograms of tilapia sold in 1979, and to 2.8 kilograms in 1984.

The problem of obtaining sufficient feed is highly related to the available supply of labor in rural areas. In such areas, feed is obtained by composting and gathering material such as leaves and termites. As the number and size of pond operations increases in a given area, families are forced to spend more time searching for and transporting feed and compost material. In contrast, some farmers in the urban area (Kananga) were able to exploit inexpensive brewery waste and consequently were less dependent on family labor to collect feeding material.

Rural secondary adopters often cited insufficient time or labor as the principal reason for abandoning ponds. Because the role of adult women and older children in pondwork is considerable, younger unwed male adopters often do not have the labor resources necessary to construct or operate large ponds. Production levels attained by rural male secondary adopters reflected the influence of the limited supply of labor available for gathering feed. The failure rate was especially high among young urban males, as most had no fields to rely on for feed supplies and limited cash resources for purchasing by-products. Interest had been keen among city youth in their teens and twenties, and they rapidly adopted pond culture. However, the combination of low levels of production, excessive theft, and the legalization of diamond digging in 1983 led to the abandonment of most urban ponds owned by younger males.

Absences due to illness or trade-related travel led to labor shortages (and to the lack of consistent management) in a number of cases. Among the 11 urban initial adopter households interviewed in the in-depth survey, 90% of the heads of household had been ill during the year preceding the survey. The average total length of illness was 8.45 weeks for those who fell ill. Three of the 10 heads of households in the rural areas were unable to take care of their ponds during the preceding year because of illness, for an average period lasting 9.0 weeks.

Trade-related absences were much more common among rural than urban households. Over 50 per cent of the rural sample reported that the male head of household had left the village to engage in trade or to attend a funeral at some time during the preceding year. The average total annual length of absence for those farmers was 12 weeks. Farmers who were absent for extended *periods usually delegated the task of feeding to women and children who may or may not have received instruction from the extension agent.*

__Theft:__ Once the ponds are built, the most important problems which emerge are theft and being able to adequately feed the fish. Farmers are encouraged to construct their ponds as near to the home as possible to facilitate surveillance of the ponds. Most theft takes place at night, when the farmer is in the fields, or out of town. Excessive theft was the major reason for abandoning ponds in the urban area and frequently caused tilapia producers to revert to extensive cultivation practices. This is particularly true for secondary adopters who may not have been able to justify the increased effort necessary to protect just one or two ares under production. Yet 50% of the urban dwellers who abandoned their ponds had no second source of income, and 95% lacked a third. The vast majority expressed a desire to restart pond culture, but were hesitant to do so unless another site could be found.

__Feed Supply:__ Adequate composting and feeding are the keys to attaining high levels of production. Natural feed supply can be augmented by encouraging plancton growth through composting and by adding leaves, termites and farinaceous by-products to the pond. Compost materials include grasses, leaves and kitchen waste as well as animal manure.

As was previously mentioned, shortages of animal manure and labor limited the amount of composting that farmers were able to do. Those in the urban area (Kananga) encountered the greatest difficulties in obtaining and transporting animal manures.

Few tilapia producers in rural areas purchased fish food. In the urban area, most farmers purchased brewery, maize or manioc waste products. These were frequently combined with many types of leaves. Purchased feed was a major expenditure item for urban fish farmers.

The relative costs of producing tilapia in Kananga using different sources of supplementary feed are indicated in Table 8. Brewery waste was by far the cheapest source of feed at the time the survey was conducted. Raising tilapia on manioc leaves or waste products would cost several times as much as raising them on brewery waste. Brewery waste was a preferred feed in Kananga because it was inexpensive.

Table 8. Conversion Value of Different Fish Feeds in Kananga, (January 1984)

FEED	Percent Crude Protein Content[a] (per 100 gms)	Conversion Rate (kg feed: kg Fish)	No. Kgs. Feed Needed To Produce 25 kgs. of Tilapia	Cost of Producing 25 kgs. of Tilapia (in Zaires)
manioc leaves	24	20	500	2715.0
termites	36	N.A.	N.A.	N.A.
manioc waste	2	13	325	1014.0
maize bran	9	10	250	500.0
rice bran	11	8	200	N.A.
brewery waste, dried	19	12	300	90.0
dried fish	50	2.5	62	609.4

N.A. Not available.
[a]As percent of dry matter. Data from Bo Gohl, Tropical Feeds, F.A.O. Rome, 1981.

Dependence on a single source of feed may involve considerable risks for farmers. The supply of brewery waste in Kananga was contingent on the availability of foreign exchange to purchase malt, machines and replacement parts. When these were not available, the brewery was forced to shut down. Thus, production of brewery waste was irregular.

Costs also may rise as the demand increases. In 1978, the brewery in Kananga usually had an excess of waste and charged users only for the cost of transporting the waste to whatever destination they selected. By the end of 1979, however, fish culture had expanded to the point where demand for the waste began to outstrip supply. The price of feed tripled but was still a bargain as a fish food. In 1980 and 1981, there was a severe cutback in supply just as interest in pond culture exploded. Concurrently, agricultural schools, facing supply cutbacks and increasing prices of animal concentrate feeds from Shaba, began to increase their proportional use of brewery waste. As a result, an intermediate stage in the selling of brewery waste developed in which an individual would purchase and dry a trailer load and then resell it by the bucket. In November 1983, the "retail" price of dried brewery waste ranged from Z1.0 to Z1.3 per kilogram compared to Z0.3 per kilogram when it was purchased directly. By the time the survey was conducted, increasing difficulties and delays in obtaining the waste caused 33% of the initial adopters interviewed and 32% of the secondary adopters to stop feeding brewery waste altogether.

Obtaining adequate amounts of feed is not a problem when an initial farmer in a given area has only a few small ponds. But as success attracts more operators, and the total number of ponds in the immediate vicinity increases, feed resources in an urban area become more limiting and labor resources in a rural area may be stretched too thin for the ponds to be intensively managed. A low level of feed supply forces operators to adopt an extensive management strategy. This means that natural production as a percent of the total quantity of fish harvested increases in significance as the area in production expands.

In the urban area of Zaire, the situation regarding by-product supply is not likely to improve markedly in the immediate future; however, a possible solution to the lack of composting material in the urban area now exists. Under a F.A.O. pilot project undertaken in 1981, sacks of inorganic fertilizer were sold on an individual basis, beginning in 1983. Although the cost of one sack is high (Z180 for 50 kilograms as of December 1984), the economic value is clear. A farmer applying 1.1 kgs/are every two weeks would only have to produce one extra kilogram of fish in order to cover the cost of the fertilizer. Production is likely to be augmented four to six times that amount due to the increased nutrient supply. As is the case with brewery waste, farmers can obtain inorganic fertilizers without having to depend on the fish project. P.P.F. does not have the facilities nor staff available to be able to sell and distribute fertilizers in the rural sector.[15]

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[15] PROPA (a Catholic Development Agency) was selling inorganic fertilizer on an affordable per kilogram basis in the Kalunga Mesu area of Dibaya at a subsidized price (transport costs from Kananga were not included).

Partial Harvesting As a Possible Management Strategy

The major production bottlenecks to increasing tilapia production in the research areas included in this study centered around the lack of sufficient feed and composting materials for intensively managing the prefered scale of operation either due to insufficient labor supply and/or lack of processed by-products. Larger operations are more difficult to manage as decisions regarding quantities to be fed to each pond and when to harvest must be made more frequently. This is especially true for farmers lacking sufficient literacy to keep adequate pond records. Therefore, any new strategies that would simplify operating the whole system, or would reduce labor time while maintaining or increasing production, should be regarded as possible improvements of a basically sound extension strategy. One approach to improving the profitability of fish culture among initial adopters is to alter the recommended harvesting strategy, i.e. shift from complete to partial harvesting.

Partial harvesting entails the netting of fish for sale or consumption without having to completely drain the pond. Under this strategy, complete drainage of the pond would not be entirely abandoned for it is essential to dry out the pond bottom occasionally to prevent disease problems and excessive stunting through overstocking. Instead of completely harvesting the pond every six months, draining would occur 11.5 months after the initial stocking, thereby setting aside 2 weeks for refurbishing the pond. One partial harvest would replace the first 6-month harvest.

There are several biological, managerial, and marketing advantages to adopting a schedule of one partial and one complete harvest annually. These are summarized below:

Biological Advantages:

1) The nutrient base established during the first 6 months of composting could be retained for an additional production period, thus reducing the labor cost inherent in establishing a plancton bloom.

2) The determination of when to partial harvest could take into account the adverse effect of colder temperatures (<22°C) on tilapia growth and reproduction rates. When initial stockings are made from January through March, the subsequent production period includes a significant number of colder dry season days. Therefore, longer production periods before partial harvesting took place (6.5 to 7 months) could be chosen. During the warmer rainy season, shorter lengths of production periods (5.5 to 6 months) could be selected by farmers able to maintain feed supplies.

Managerial Advantages:

1) Pond management would be simplified as the farmer could schedule harvesting and draining each pond at a particular time each year, e.g. pond X could always be drained in February and pond Y in October.

2) Complete drainage of the pond would be avoided in those months where refilling of the pond would be difficult owing to insufficient rainfall, e.g. during June, July, and August.

3) Complete drainage could also be avoided during periods of heavy rainfall to avoid substantial damage to the cut dikes. In addition, it is difficult to dry out pond bottoms completely during the wettest months of the year (November, March, April).

Marketing Advantages:

1) The scheduling of both partial and complete harvests could be organized around times of seasonal requirements for additional food or cash.

2) Partial harvesting provides a more flexible means of minimizing the price effects of excess supplies of tilapia appearing at times when large quantities of competing sources of protein are available. Partial harvesting could be carried out over several days if necessary. This is less expensive than harvesting a large volume and smoking or drying the surplus.

The major drawback of partial harvesting is that this would necessitate the use of imported netting. The fine-meshed seine netting ideal for trapping fingerlings is not now manufactured in Zaire. Large-meshed gillnets, on the other hand, are occasionally sold in Kananga. Lovshin and Pretto-Malca (p. 503) reported that they were able to harvest tilapia in Panama employing 2-, 3-, and 4-inch stretch mess gillnets. The use of gillnets was preferred because they were locally available, cheaper, and easier to handle than an equivalent length of seine net. In addition, tilapias can readily pass under a seine net in deeper water. However, locally-manufactured gillnets in Zaire are much less durable than seine nets and therefore require frequent repair. They are also inappropriate for capturing fingerlings for stocking ponds as they tend to inflict greater physical damage than do seine nets. If only one type of netting were to be stocked and sold by the project, the seine net would be preferable in that it can perform both functions and would last longer. Although hardier than gillnets, seine nets are more difficult to repair, and farmers would have to be admonished to refrain from using the nets for river fishing owing to the harsh conditions encountered. Regardless of which type of netting was chosen, more time would have to be spent instructing farmers on proper maintenance and repair techniques than has typically been done in the past.

The sale and distribution of whatever netting was chosen would have to be done judiciously, as meeting the demand of the entire community would be extremely costly. When a program is first being established, the extension agent is better able to insure quality pond construction if he/she controls the availability of the fingerling supply in the area. Once several initial adopters begin harvesting, nets could be used as an incentive to encourage better management techniques. For instance, a farmer who had obtained high average yields (given the available resource base) for three or more harvests would be able to purchase a net. Hopefully, by this stage the farmer would have grasped the concepts of tilapia culture well enough so that the net would not be used to overfish the pond between harvest times.

Engaging in the sale of nets would create an unwanted "dependency" on the project. For this reason, it would be desirable to persuade local manufacturers to make finer-meshed netting.[16] Alternatively, the project could encourage the development of rental schemes whereby an individual would hire a net-owning farmer to help him/her harvest. In the past, the extension service has been fairly successful in

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[16] Several local businessmen in Kananga remarked that small-meshed netting was not produced in Zaire because the government wanted to discourage the removal of fingerlings from the rivers, but the validity of this statement was not verified by the author.

establishing guidelines for base prices for fingerlings sold by project farmers to new participants. It is likely that farmers would be receptive to the rental scheme idea if a fair value for their services could be established. Moreover, this undesirable aspect of net distribution is not as serious as the problems that would be encountered in distributing other inputs such as inorganic fertilizers.

Overall, the positive attributes of adopting a partial harvesting strategy in terms of enhancing total output and self-sufficiency of operation outweigh the negative features. It should be stressed, however, that this approach can only be recommended for areas like Kasai Occidental where schistosomiasis (bilharzia) is not endemic in local waters. For this reason, it would not be an appropriate strategy in either Kasai Oriental or Bas Zaire.

<u>Comparison of Returns Under Alternative Assumptions Regarding the Availability of Labor and Feed</u>

Simple budgets were constructed to compare the effects of differing labor resources on fish culture profitability in the urban and rural sectors. The budgets are based on a 6 are pond assuming relative prices similar to those which prevailed in Zaire in January 1984. Values in subsequent years are expressed in constant 1984 Zaires. Each household is assumed to have constructed a 2 are pond in each of 3 consecutive years with the rural operator developing a forested site with clay soils and the urban operator exploiting a sandier site with few trees. Present values were calculated using a real discount rate of 12%.[17]

In the rural area, the financial cost of labor as determined by the salary earned by a state agricultural worker was assumed to be

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[17] In countries with a high inflation rate, it is particularly difficult to determine the real rate of interest. In an extreme case like Zaire, the real rate is probably low, or even negative. Twelve percent, however, is a real rate commonly used for project analysis in developing countries (Gittinger, p. 314). The nominal discount rate for Zaire would be much higher than 12%. One plausible value for the nominal rate is given by annual interest rates on Treasury bonds issued in April 1983: 40% for bonds held for 28 days, 42% for 56 days, and 45% for 91 days (Q.E.R. (1984), p. 10).

(Z14.2/day).[18] Based on the weekly expenditures of crop cultivating households near Kananga, the social opportunity cost of agricultural labor for the urban area was assumed to be twice the foregoing rate (Z28.4/day). Assumptions regarding labor input were based on more detailed interviews from a limited number of rural households.

Comparative values of a 6 are system in two rural sites with equivalent construction costs, but differing amounts of family labor available for feeding and composting the ponds are shown in Table 9.[19] Both households were assumed to have access to leaves, termites, and limited quantities of animal manures, and to have been able to attain good yields of 40 kilograms per are per year in their first year of operation. It is reasonable to assume that there are few economies of scale in feeding and composting ponds when leaves and termites are the principal feeds. Thus, in case A, a household desiring to maintain the high yields of the first year would have to multiply the time involved in gathering the necessary quantity of feed accordingly. In this instance, the labor requirement increases from 45 to 270 person-days per year as the pond system expands from 1 to 6 ares. The net present value of the 15-year operation would be Z33,520, with payback on the investment occurring by the end of the first two years of operation.

Case B is a much more realistic assessment of what is likely to happen in a rural setting. The household has a limited quantity of labor to devote to feeding and composting activities. As the size of the operation expands, yields fall but total production rises, and hence, total revenue increases. In the second and third years of operation, it is assumed that a maximum of 100 person-days of labor would be available to devote to managing the ponds. In subsequent

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[18] As of January 1984, the lowest level of salaried government labor was for agricultural workers; Z368 per month divided by 26 working days equals Z14.2 per day.

[19] No constraint on the amount of supplemental labor available for construction was assumed because of survey results showing that farmers usually employed neighbors or relatives in building the ponds. Much of this labor force (young men, in particular) would disperse once building was completed and would not be incorporated into the labor pool involved in feeding and composting.

Table 9. Net Present Worth of a Hypothetical Pond Operation in a Rural Area[a]

A. Maintaining High Yields: No Labor Constraints

	Cost (in Zaires)						Value (in Zaires)		
YEAR	Canal & Pond System[b]	Operating Labor[c]	Finger-lings	Shovel	TOTAL COST	Yield (kg/are/year)	TOTAL REVENUE	Net Benefit	NET PRESENT WORTH at 12%
1	2130	639	40	130	2939	40	1800	-1139	-1017
2	1988	1917	-	-	3905	40	5400	1495	1192
3	1988	3195	-	130	5313	40	9000	3687	2625
4	-	3834	-	-	3834	40	10800	6966	4430
5-15	-	42174	-	-	42174	40	118800	76626	26290
								TOTAL:	33520

B. Labor Constraint For Feeding and Composting Activities

	Cost (in Zaires)						Value (in Zaires)		
YEAR	Canal & Pond System	Operating Labor	Finger-lings	Shovel	TOTAL COST	Yield (kg/are/year)	TOTAL REVENUE	Net Benefit	NET PRESENT WORTH at 12%
1	2130	639	40	130	2939	40	1800	-1139	-1017
2	1988	1420	-	-	3400	29	3915	507	404
3	1988	1420	-	130	3538	18	4050	512	365
4	-	1708	-	-	1708	18	4860	3152	2005
5-15	-	18788	-	-	18788	18	53460	34672	11895
								TOTAL:	13652

[a]Based on a proposed 6 ares operation (600 square meters). All values in constant January 1984 Zaires (Z30.12=$1). One kilogram of tilapia valued at Z45. Price of labor equal to Z14.2 per day (salary of state agricultural worker).

[b]Forested area with clay soils: 2 ares constructed in each of 3 consecutive years. Assumed 150 person-days used in initial year; 140 person-days in years 2 and 3.

[c]In evaluating costs for composting, feeding, maintaining, and harvesting the ponds, no economies of scale were assumed. The pond was harvested only once in the year it was constructed; twice in all subsequent years. For pond operators maintaining high yields, 45 person-days of operating labor were assumed; 135 for the second year; 270 in subsequent years. For pond operators with a limited quantity of labor available, the following assumptions were made: 45 person-days of labor in the initial year; labor input was restricted to 100 person-days in years 2 and 3; An additional increment of 20 person-days became available for managing the system in subsequent years once construction had been completed.

years, an additional 20 person-days of labor was included as a certain amount of the family labor involved in pond construction would then become available. Net present value was still positive, but much lower than for the high yield scenario, and an additional year was required to realize the payback on the investment.

In the urban area, having a regular supply of brewery waste available as feed makes a significant impact on the positive net worth of the operation. This is due to the low cost of feed per kilogram of fish produced combined with the reduction of time spent in feeding activities. Both leaf and brewery waste feeding households faced lower labor input demands for constructing pond systems in the non-forested urban setting (Table 10). Lower total costs plus higher yields resulted in the net present value of the brewery waste feeding operation being 1.5 times that of the rural household maintaining good yields.

The sensitivity of the calculated net present value to the price attributed to labor is evident in the urban leaf and termite feeding household. Even though the labor input involved in construction was only one-third that required in the rural area, the higher cost of daily labor meant that the net present value for this system was only Z5147, less than half that found for the rural system facing similar labor constraints.

Several points of interest emerge from this analysis. First, it would be advantageous to either rural or urban households to have credit facilities available so that the construction of the entire system could be completed as rapidly as possible. Benefits would then accrue at an earlier stage. The ability to hire additional labor for feeding and composting so that higher yields could be maintained would be advantageous as well. In the urban sector, the availability of credit might permit poorer farmers to purchase brewery waste in bulk, although the principal problem in this case is limited supply not inadequate cash resources. However, as it now stands, credit facilities are virtually non-existent, and even if they did exist, interest rates would be exorbitant given the high opportunity cost of capital.

Table 10. Net Present Worth of A Hypothetical Operation in an Urban Area[a]

A. Brewery Waste Feeding Household

	Cost (in Zaires)							Value (in Zaires)		
YEAR	Canal & Pond System[b]	Operating Labor[c]	Finger-lings	Shovel	Purchased Feed	TOTAL COST	Yield (kg/are /year)	TOTAL REVENUE	Net Benefit	NET PRESENT WORTH AT 12%
1	1420	398	40	130	162	2150	45	2025	-125	-112
2	1278	1193	-	-	720	3191	50	6750	3559	2837
3	1278	1988	-	130	1080	4476	50	11250	6774	4823
4	-	2386	-	-	1080	3466	50	13500	10034	6382
5-15	-	26246	-	-	11880	38126	50	148500	110374	37868
									TOTAL:	51798

B. Leaf and Termite Feeding Household With a Labor Constraint

	Cost (in Zaires)							Value (in Zaires)		
YEAR	Canal & Pond System	Operating Labor	Finger-lings	Shovel	Purchased Feed	TOTAL COST	Yield (kg/are /year)	TOTAL REVENUE	Net Benefit	NET PRESENT WORTH AT 12%
1	1420	1278	40	130	-	2868	40	1800	-1068	-954
2	1278	2840	-	-	-	4188	29	3915	-203	-162
3	1278	2840	-	130	-	4248	18	4050	-198	-141
4	-	3408	-	-	-	3408	18	4860	1452	923
5-15	-	37488	-	-	-	37988	18	53460	15972	5481
									TOTAL:	5147

[a]Based on a six ares operation (600 square meters). All values in constant January 1984 Zaires (Z30.12=$1). One kilogram of tilapia valued at Z45. Price of labor was assumed to be Z28.4 per day.

[b]Sandy area with a few trees: 2 ares constructed in each of 3 consecutive years. Assumed 50 person-days used in initial year; 45 person-days in years 2 and 3.

[c]No economies of scale were assumed. For brewery waste feeding households 14 person-days of operating labor were assumed per are of production: a total of 14 person-days required in the first year, 42 the second, 70 the third, and 84 in all subsequent years. For the urban leaf and termite feeding household, the same assumptions regarding operating labor as those made for the rural household with a labor constraint were made.

One of the most economical ways for farmers to expand the size of their systems would be to purchase partially cleared sites or abandoned ponds adjacent to their existing operations. The low cost per square meter values for valley land in Kananga has been mentioned previously, and such purchases are already occurring. In the rural sector, however, pond sites are more spread out and less frequently abandoned. The return to labor for urban pond operations not having access to farinaceous by-products is limited. On the other hand, future development of pond systems near rural centers with milling facilities could prove to be highly profitable. In the long run, however, the most viable system sustainable on a widespread basis in Zaire will remain the small-scale rural operation utilizing "excess" family labor when available to produce supplemental income and food for home consumption.

Conclusions and Recommendations

Tilapia production is a labor intensive operation that provides a high gross return per unit of land in both the urban and rural areas. Once established, the return to labor from an intensively managed rural pond operation appears to be comparable to or surpass that gained from maize or peanuts.

In its first five years of existence in Kasai Occidental, Projet Pisciculture Familiale not only survived but expanded and prospered during a time of increasing economic chaos. The high cost of maintaining a direct contact extension program was accentuated by the lack of sufficient infrastructure and technical inputs that characterize Zaire's agricultural sector. The success of the project in reaching farmers was due mainly to its small size which minimized administrative problems as well as corruption.

While favorable prices for fresh tilapia encouraged the adoption of intensive techniques, they did not guarantee their continued practice. In rural areas, the availability of labor for feeding activities ultimately determined whether the ponds were extensively or intensively managed. A large number of farmers learned the basic techniques of tilapia culture and benefited mainly by having fish available for home consumption and an emergency source of cash. Farmers with access to greater resources were able to generate significant amounts of supplementary income from their tilapia ponds.

In spite of the high cost per farmer, the experience in Zaire suggests that in the introductory phase, it is preferable to work intensively with a small group of older, relatively successful farmers.[20] Older farmers not only are likely to have a larger pool of family labor on which to draw for constructing and managing ponds, but also greater financial resources for hiring additional assistance if needed. Successful farmers generally were able to build larger ponds and thus guarantee an adequate supply of fingerlings to others in the area. Since the role of adult women and older children in pondwork is considerable, younger unwed male adopters often do not have the labor resources necessary to construct and maintain large operations. An adequate supply of labor is particularly essential to gather feed for the fish, especially in rural areas.

Once the program has been accepted, it is desirable to work with a broader range of families because of the significant benefits that such families may obtain even if ponds are only extensively managed. Adding participants is important from the standpoint of improving welfare and nutrition in the poorest households. However, expectations regarding productivity must be lowered accordingly.

When working with secondary adopters, emphasis should be placed on site selection and pond construction—the foundation of the entire operation. For those households headed by younger men in their twenties and thirties, the principal goal should be to achieve a level of "en-

[20] The concurrent failure of a different fish extension program operating in the same zone of Zaire confirms the necessity of stressing the "quality" as opposed to the "quantity" approach in the beginning phases of an extension effort. In this case, the PROPA development agency sought to help as many people as quickly as possible and adhered to the policy of distributing fish to any farmer who had water available, regardless of whether a pond of adequate size and strength had been constructed. Not one of the hundreds of "PROPA-stocked" ponds was observed functioning three years later. Farmers abandoned operations after dikes broke during heavy rainstorms, or because they were discouraged by low yields.

hanced subsistence," i.e. knowing how to restock and manage at least 2 ponds. Although teaching management techniques to secondary adopters should not be ignored, greater reliance could be placed on less costly secondary materials and group seminars. Younger farmers often have received more schooling than those over 40 years of age, permitting more extensive use of written educational materials. Secondary adopters should not be encouraged to expand the size of their operation beyond a few ares. Direct extension contact with regard to management skill should be concentrated on the initial adopters because high yields demonstrated at harvest times are the most effective means of conveying the importance of consistent feeding and composting to other farmers. On the household level, greater emphasis should be placed on adequately training all members who are responsible for feeding the fish, especially adult women.

Two of the major limitations to successful pond production are pilfering (particularly in urban areas) and a shortage of feed. Most of the individuals engaged in tilapia farming possess the management skills necessary to generate additional surplus production for sale if they could more easily obtain additional feed. Given present conditions, the extension efforts in urban areas should concentrate on "model" farmers because they are the only ones capable of sustaining their operations in the long run. The poorest urban dwellers benefit more by having low-cost fresh fish available in the market than by engaging in pond culture when they lack adequate resources and are extremely vulnerable to pilfering. Both rural and urban fish farmers could enhance the productivity of their operations by shifting to a strategy of one partial harvest and one complete harvest annually in lieu of complete harvesting every six months. The use of inorganic fertilizers and the possibility of smoking tilapia from larger harvests appear to be economically viable options for some farmers in the urban area.

When all of the land, material, labor and social costs are taken into account, five factors emerge as essential criteria for ensuring long-term sustainability of tilapia production. These are:

1) *the building of ponds that can withstand heavy rainfall in well-selected sites,*
2) *self-sufficiency in fingerling supply,*
3) *stable, good health for the principal fish farmer,*
4) *the lack of excessive theft, and*
5) *the existence of an adequate labor supply for feeding the fish or the availability of inexpensive supplementary feeds.*

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APPENDIX A. CHARACTERISTICS OF SURVEY HOUSEHOLDS

The average number of persons living on a parcelle[1] did not vary much among the different areas for pond-owning households (I+S+D). The average ranged from 8.5 to 10.5 persons per household (see Table A1). The mean for non-participant households was lower in all three research areas, from 6.0 to 7.0 persons per household.

Table A1. Characteristics of the Household Structure

Category	Total Number of: House-holds	Persons on the Parcelle (mean)	Years on the Parcelle (median)	Age of the head of household (mean)	No. of Wives per male head of household (mean)
Luiza					
I+S+D	17	10.5	12	42.4	1.4
N	12	6.0	7	39.0	1.0
Dibaya					
I+S+D	27	9.3	20	48.5	1.2
N	4	7.0	2	43.3	0.8
Kananga					
I+S+D	72	9.3[a]	18	48.0	1.0
N	21	6.0	5	39.5	1.0

[a]This figure is somewhat higher than the 7.3 persons per parcelle recorded for Kananga in the 1974 population survey (I.N.S., p. 34).

Median values were included for the total number of years on the parcelle as several of the means were biased due to one particularly high or low data point. The averages for this statistic in all three areas were significantly lower for the non-participant sample than for the pond-owning households. The median years on the parcelle for the latter ranged from 12 to 20 versus 2 to 10 for the non-participant households.

[1] Parcelle is literally translated as the home owner's lot. It is used here to distinguish between a household and the actual land, since more than one household can be found living on a single parcelle.

The differences noted between the pond-owning and non-participant groups may be a reflection of the younger average age of the non-participants found in this survey. Initial adopters of fish pond culture were generally in their mid-forties to late fifties. It is not unreasonable to speculate that they probably had access to better land than did the non-participants as they were older and had been established in the area for a longer period of time. In addition, the greater number of persons living on their parcelle could be indicative of a larger labor pool to draw on for constructing and managing the ponds. The highest incidence of polygamy in all categories was found among households in the Luiza Zone.

A higher proportion of females to males was reported in all Luiza households, and in the Dibaya households as well, excluding the initial adopters (47 vs. 52%). The opposite was true among urban families, with the male members of the household in Kananga outnumbering the females. As was expected, the household composition was dominated by youths. Approximately 50% of all household members were under 15 years of age.

The majority of the principal fish farmers in this survey were also the male heads of the households. There were instances, however, in which a woman or the son of the head of the household was in charge of the ponds. The major characteristics of the 116 fish farmers interviewed are given in the following table.

Table A2. General Characteristics of Principal Fish Farmers

Category	Age	Percent of Farmers that are Female	Number of Years Farmer Studied (Mean)
Luiza			
I	44.5	0	5.9 (2.1)[a]
S+D	35.8	0	5.8 (1.7)
Dibaya			
I	54.5	0	4.8 (1.9)
S+D	38.9	8.3	5.4 (2.9)
Kananga			
I	46.7	0	8.8 (3.2)
S+D	42.5	10.0	7.4 (3.3)

[a] Number in parentheses is the standard deviation of the mean.

APPENDIX B. DRYING TILAPIA AS A POSSIBLE MARKETING STRATEGY

Farmers raising smaller quantities of tilapia (<15 kgs.) encountered few problems in the marketing of their fish. The question arises whether those farmers capable of producing larger quantities of tilapia (>35 kgs. per harvest) would be better able to deal with the vagaries of the marketplace if they were to dry their fish, and thus, not be as subject to depressed prices when supplies are large.

The economics of drying tilapia for the urban market was analyzed by gutting and smoking approximately 10 kilograms of fresh tilapia at the regional fish station in Kananga and determining the price at which the smoked tilapia would have to sell so that at least the equivalent fresh tilapia price would be obtained. The objective was to ascertain whether or not the cost of both small and large smoked tilapia would be price competitive with other dried fish on the market.

Representative samples of the various kinds of fish available in Kananga were purchased and weighed in November of 1983. The comparative values of these are presented in Table B1. The higher price per kilogram found among dried as opposed to fresh fish was expected as the latter have lost more than 50% of their original weight in the drying process. More surprising, however, was the lower cost of the imported salted makaiyabo than the locally produced tilapia (Z62 per kilogram vs. Z69). The high price of dried eels and catfish compared to fretins, mikebuka, and mayanga helps explain why they are less frequently consumed.

Details of the drying trial, and the results are reported in Table B2. Smaller fish (<14 cms. in length) lost a greater percentage of their weight (72%) than did the larger fish (60%) and required more labor input to clean. Although it took longer to smoke the larger fish, fewer technical problems were encountered than with the small fish. The latter were more likely to burn or fall through the rack made of local palm rachises. When the variable labor cost was included, large

Table B-1. Comparative Value of Different Kinds of Fish in the Kananga Market, November 1983

KIND OF FISH		COST: ZAIRES PER KILOGRAM
Salted fish (makaiyabo)		61.9
Dried:	Catfish (tubobo)	359.3
	Eels (tushi)	390.6
	Mikebuka	184.7
	Fretins	166.8
	Mayanga	107.2
Canned sardines[a]		160.7
Frozen mackerel (mpiodi)		98.1
Fresh tilapia		68.8

[a]Sardines were packed in oil. The fish were removed from the can and all excess oil drained off before weighing. Canned pilchards were also available—a 450 gram can cost Z25. However, the individual fish were not weighed separately from the sauce and therefore, the cost for kilogram figure was not included for pilchards in this table.

tilapia would have to sell for at least Z108 a kilogram, making them price competitive with other dried fish on the market. The smaller fish would be competitive with all dried fish, except for the mayanga. Salted fish would still remain a cheaper alternative.

The evidence suggests that for farmers with large harvests it might be profitable to dry tilapia that are at least 30 grams in weight. However, it should be noted that fresh tilapia approximately 75 grams or more usually sell much faster than smaller fish, and make up a smaller proportion of the total harvest. It would be beneficial, therefore, to explore new approaches to smoking smaller tilapia that would overcome the problems mentioned above.

Table B-2. Value of Smoking Fresh Tilapia in Kananga, November 1983.[a]

Condition of Fish	Weight of Sample (kgs.)	No. Fish per kg.	% Change in weight	PRICE PER KILOGRAM without labor cost[b]	with labor cost[c]
Large Fish[d]				(Zaires)	(Zaires)
Whole	5.00	15.0		40.0	—
Gutted[e]	4.50	16.6	-10	44.4	44.8
Smoked	2.00	38.0	-60	100.0	108.2
Small Fish					
Whole	4.47	62.0		35.0	—
Gutted	4.24	62.0	- 5	36.8	37.7
Dried	1.25	221.0	-72	125.0	130.6

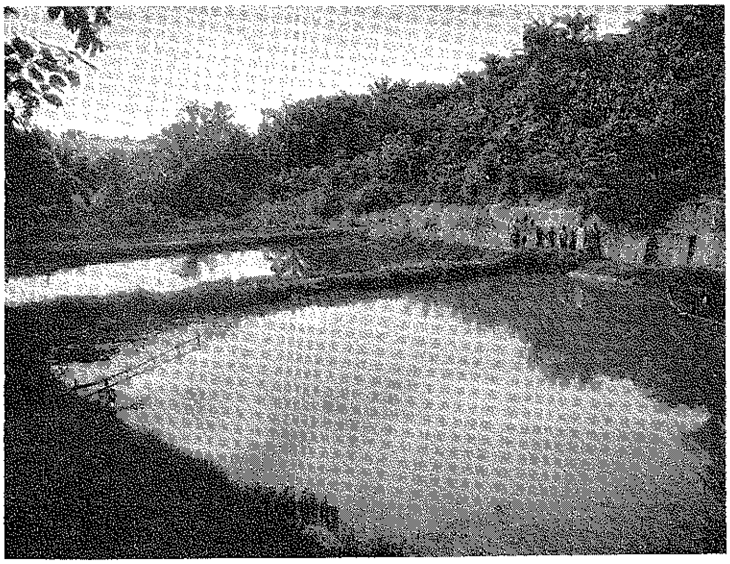
[a]Based on a smoking trial conducted using Oreochromis niloticus at Katuishi fish station in November 1983.

[b]The price for large tilapia was that obtained at the station in November 1983. The price for small tilapia set by the fish station (Z25) was far below the going average price demanded by project farmers (Z35). The latter was used to estimate the price at which smoked tilapia would have to sell in order to earn the equivalent of the fresh fish.

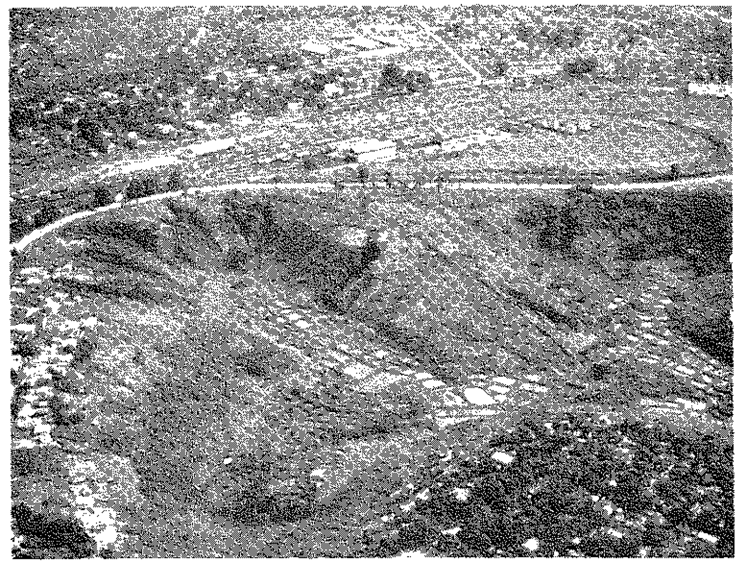
[c]Labor costs were calculated using wages paid to station labor. Workers received Z15 per 7 hour work day. Inputs were measured for smoking 9.47 kgs. of tilapia: 14.0 person-hours to collect wood (8 one meter long pieces plus .5 cubic meter of smaller sticks); cleaning of the large and small fish took 1.0 and 1.8 person-hours, respectively. Smoking all the small fish required only 3.25 hours compared to 11.67 hours to completely dry the larger fish. Fixed labor costs for constructing the mud-walled, thatched roofed hut measuring 2.9 cubic meters for smoking were not included.

[d]Large and small fish were separated by length (not weight) for expediency. All tilapia greater than or equal to 14 cm in length were classified as large.

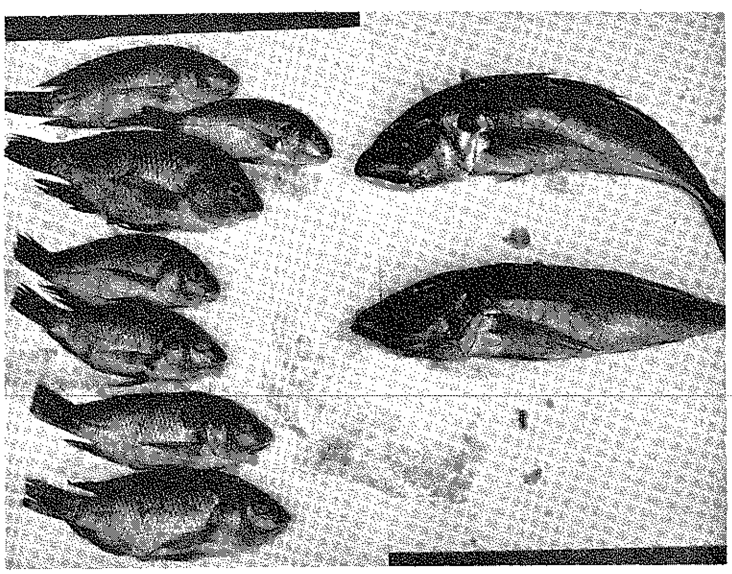
[e]Fish were gutted, but not scaled.



(1)
Adjacent 3-are ponds in a valley floor. The fence in the corner holds the composting material.



(2)
Aerial view of one valley full of both initial and secondary adopters in Kananga.



(3)
Equivalent value (Z20) of Oreochromis niloticus from the market and its major competitor in the city, frozen mackeral (mpiodi).

(4)
Farmer Mukengeshai Tshibalabala constructing a dike for the pond shown in (1) using clay soil cut from the adjacent hillside.

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